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## (54) METHOD FOR MELTING EXTRA-LOW CARBON STEEL EXCELLENT IN CLEANLINESS

### (57)Abstract:

PROBLEM TO BE SOLVED: To provide a melting method of an extra-low carbon steel excellent in the cleanliness, with which the decarburizing speed at the decarburizing treating time under vacuum state is not damaged and reoxidation of molten steel from molten slag in a ladle is restrained and the clogging of an immersion nozzle at the continuous casting time is prevented.

SOLUTION: In the method for producing the extra-low carbon steel by executing deoxidizing treatment after executing the decarburizing treatment to the molten steel in the ladle under vacuum state, the composition of the molten slag in the ladle in the vacuum treating process is adjusted so that the composition of the molten slag in the ladle after completing the deoxidizing treatment becomes by w.t.% of 30-60% CaO, ≤10% SiO<sub>2</sub>, 20-50% Al<sub>2</sub>O<sub>3</sub>, 10-20% MgO and 5-15% the total of FeO and MnO.

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## CLAIMS

[Claim(s)]

[Claim 1] In the approach of manufacturing super-low carbon steel by carrying out deoxidation processing after carrying out decarbonization processing of the molten steel in a ladle under a vacuum the presentation of the molten slag in the ladle after deoxidation processing termination by weight % CaO: 30-60%, SiO<sub>2</sub> : 10% or less, aluminum 2O<sub>3</sub> : So that the sum total of 20 - 50%. MgO:10-20%, and FeO and MnO may become 5 - 15% The ingot approach of super-low carbon steel of having excelled in vacuum down stream processing at the detergency characterized by adjusting the presentation of the molten slag in a ladle.

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the ingot approach especially characterized

by adjustment of the molten slag presentation in the ladle in vacuum down stream processing about the ingot approach of super-low carbon steel excellent in the dergency. [0002]

[Description of the Prior Art] Super-low carbon steel is used for the steel plate for sheathing of the automobile by which it is required that surface discontinuity should be excellent in a moldability few, and in case it is an ingot, super-low carbonization and the cure against the Takakiyo purification of steel are taken.

[0003] As the decarbonization approach at the time of ingotting super-low carbon steel, the method of making non-deoxidized molten steel cause an decarbonization reaction under a vacuum is common. That is, it is decarbonized until carry out tapping of the non-deoxidized molten steel whose carbon content is 0.02 - 0.1 % of the weight to a ladle, it makes the oxygen supplied from the outside, such as oxygen in molten steel, or a slag in a ladle, under a vacuum, and the carbon in molten steel react after that and carbon content becomes 0.001 - 0.005% of the weight from steel-manufacture furnaces, such as a converter.

[0004] It is known that the oxygen content in molten steel required in the case of the above-mentioned decarbonization reaction in order to obtain sufficient decarbonization rate is 0.04 % of the weight or more. When obtaining molten steel with such high oxygen content at steel-manufacture furnaces, such as a converter, the sum total of the content of FeO and MnO which is a low-grade oxide in a slag becomes high with about 15 - 20 % of the weight.

[0005] In the super-low carbon molten steel which performed deoxidation processing by aluminum after decarbonization processing under a vacuum, by the time the continuous casting usually used is completed, aluminum in molten steel and the low-grade oxide in a slag will react. The oxide (aluminum 2O3) of aluminum generates by this reaction. A part of this oxide remains in a cast piece, without being removed from the molten steel in tundish and mold during continuous casting, it serves as nonmetallic inclusion, and worsens the dergency of steel.

[0006] This aluminum 2O3 It may become the surface discontinuity of the steel plate for sheathing of an automobile, and the nonmetallic inclusion of a system may become the cause which is easy to accumulate near the front face of a cast piece, therefore a submerged nozzle blockades during continuous casting. If a submerged nozzle blockades, channeling arises in the molten steel which \*\*\*\*\* becomes impossible and productivity is not only checked, but passes through the inside of a submerged nozzle, the flow condition in mold will change, the oxide of aluminum etc. will be accumulated near the front face of a cast piece, and surface discontinuity will arise for a product. In order to prevent lock out of this submerged nozzle furthermore, it will be necessary to increase the flow rate of inert gas, such as Ar blown from the upper part of a submerged nozzle. When the inert gas blown so much is also caught near the front face of a cast piece and remains, it becomes the cause of the surface discontinuity of a product. In order to prevent the surface discontinuity of such a product, taking care of a cast piece and the hot-rolled front face of the material for steel plates poses a big problem from the field of economical efficiency or productivity.

[0007] Then, the cure which lowers before the decarbonization processing under the time of tapping from steel-manufacture furnaces, such as a converter, or a vacuum has been taken [ content / of low-grade oxides, such as a lifting, FeO in the slag in a cone ladle, and MnO ] in aluminum and the reaction in steel.

[0008] For example, by the approach indicated by JP,5-239537.A, the approach of adding a slag modifier to the slag in the ladle in lapping from a converter or after tapping, making content of the sum total of FeO and MnO in a slag it to 5 or less % of the weight, blowing a top after that before the decarbonization processing under a vacuum, and spraying oxygen gas on the front face of the molten steel in a vacuum tub from a lance is taken.

[0009] Although it blows on the molten steel front face in a vacuum tub a top and oxygen gas

is sprayed from a lance by this approach, that reason is that the oxygen supply from the low-grade oxide contributed to an decarbonization reaction falls, and oxygen required for an decarbonization reaction runs short in order to make low content of the low-grade oxide in the slag before the decarbonization processing under a vacuum by slag reforming. However, with the oxygen gas sprayed on the molten steel front face in a vacuum tub, Fe, Mn, etc, in molten steel oxidize, low-grade oxides, such as FeO and MnO, are generated, and the content of the low-grade oxide in a slag becomes high after all. Moreover, since a lot of modifiers and fluxes are added in tapping in order to make content of the sum total of FeO and MnO in the slag after tapping 5% or less, there are problems, like descent of the molten steel temperature in a ladle is large.

[0010] On the other hand, after decarbonization processing under a vacuum and performing deoxidation processing by aluminum, by adding the flux of an oxide system to the molten steel in a vacuum tub, aluminum and the reaction in steel reduce the content of low-grade oxides, such as a lifting, a cone FeO, and MnO, or the cure which intercepts the slag in a ladle and the interface of molten steel has been taken.

[0011] In JP,3-183722,A, after decarbonization processing under a vacuum and performing deoxidation processing by aluminum, the oxide which uses MgO as a principal component at the molten steel in a vacuum tub is added, and the method of making this oxide placed between the interfaces of a slag and molten steel is indicated. It is the approach of carrying out 2-5kg / molten steel t grade addition of the MgO from tubing immersed in the chute in a vacuum tub, or the ladle besides a vacuum tub.

[0012] By this approach, since there are too many additions of MgO, MgO does not distribute to homogeneity but solidifies in the interface of a slag and molten steel partially, the effectiveness of MgO addition is stabilized, and may not be acquired or the temperature of the molten steel in a ladle may fall greatly. Therefore, it is necessary to spray oxygen gas on the molten steel front face in a vacuum tub, and to raise the temperature of molten steel, and there is a problem that only the steel inferior to a detergency is obtained after all.

[0013]

[Problem(s) to be Solved by the Invention] Without spoiling the decarbonization rate at the time of the decarbonization processing under a vacuum, this invention controls reoxidation of the molten steel from the molten slag in a ladle, and prevents lock out of a submerged nozzle in the case of continuous casting, and aims at offering the approach of ingotting the super-low carbon steel excellent in the detergency.

[0014]

[Means for Solving the Problem] After the summary of this invention carries out decarbonization processing of the molten steel in a ladle under a vacuum, in the approach of manufacturing super-low carbon steel by carrying out deoxidation processing, the presentation of the molten slag in the ladle after deoxidation processing termination is weight %. CaO. 30-60%, SiO<sub>2</sub> : 10% or less, aluminum 2O<sub>3</sub> : So that the sum total of 20 - 50%, MgO:10-20%, and FeO and MnO may become 5 - 15% If is in the ingot approach of super-low carbon steel of having excelled in vacuum down stream processing at the detergency which adjusts the presentation of the molten slag in a ladle.

[0015] The carbon content of the target super-low carbon steel is about 0.005 or less % of the weight of steel in this invention.

[0016] The process of the decarbonization processing under vacuum down stream processing as used in the field of this invention, i.e., a vacuum, and deoxidation processing means down stream processing using ring current mold vacuum processors, such as RH and DH. In order to ingot the super-low carbon steel which was excellent in the detergency with such vacuum down stream processing, it is effective after the deoxidation processing after carrying out decarbonization processing under a vacuum to prevent reoxidation of the

molten steel from the molten slag in a ladle. As mentioned above, in the super-low carbon molten steel which performed deoxidation processing by aluminum, it is because the low-grade oxide in aluminum in molten steel and the molten slag in a ladle reacts.

[0017] In order to prevent reoxidation of the molten steel from the molten slag in a ladle, the approach of intercepting the molten slag in a ladle and the interface of molten steel is the most effective. As an approach of intercepting such an interface, it is most effective to make the molten slag after deoxidation processing crystallize solid phase. It is the molten slag of a liquid phase condition for the reason to contact the molten steel in a ladle directly, and to make molten steel reoxidate, and it is because the reoxidation rate of molten steel falls remarkably in the case of the slag of solid phase and reoxidation of parenchyma and molten steel does not take place to it.

[0018] It carried out the knowledge of the important thing especially that this invention persons choose appropriately the stage to make the molten slag in the ladle after deoxidation processing crystallize this solid phase. namely, aluminum 2O3 rather generated in molten steel after the time of deoxidation processing, and deoxidation processing at this stage rather than reoxidation of the molten steel by molten slag arose until it started continuous casting after deoxidation processing termination etc. -- an oxide surfaces the inside of molten steel and the molten slag in a ladle is adsorbed. That is, reoxidation of the molten steel by the molten slag in a ladle needs to control during the continuous casting after starting continuous casting. That is, if the molten slag in a ladle is made to crystallize solid phase, it is effective for the stage to start the continuous casting after deoxidation processing.

[0019] Furthermore, this invention persons did the knowledge of the ability to make molten slag crystallize solid phase at the stage to start continuous casting by considering the presentation of the molten slag in the ladle after deoxidation processing as the presentation mentioned above.

[0020] Although it changes a little with capacity of the tundish of a ladle and continuous casting, the degree of superheat to the liquidus-line temperature of the temperature of the molten steel in a ladle and the molten steel in tundish is made into the temperature which usually had the degree of superheat of the moderate range. If a degree of superheat is too low, since the temperature in a ladle will fall with time amount, molten steel solidifies quickly and it becomes impossible to cast within a ladle, tundish, or mold in the middle of continuous casting. Moreover, if a degree of superheat is too high, the coagulation husks in mold will fracture and it will become easy to generate a breakout. Furthermore, it is mostly decided with the carbon content of steel that the liquidus-line temperature of a proper will be steel. Therefore, it is desirable for target C [ this invention ] content to make molten steel temperature in the ladle at the time of continuous casting initiation of 0.005 or less % of the weight of super-low carbon steel about 1590-1620 degrees C. In addition, the temperature of the molten slag which is in contact with the molten steel in a ladle, and molten steel is almost the same.

[0021] When making the molten slag in the ladle after deoxidation processing crystallize solid phase from this with the stage, i.e , the temperature of 1590-1620-degree C molten slag, to start continuous casting, it turned out to reoxidation prevention of molten steel that it is effective.

[0022] If the solid phase of at least 1 - 2 volume % extent is made to crystallize in molten slag at this time, reoxidation of the molten steel by molten slag can be prevented. Since the viscosity of molten slag increases to extent mentioned above and volume % (it is hereafter described as the rate of solid phase) which solid phase crystallizes to molten slag can control the mass transfer by the side of molten slag at least to it, reoxidation of molten steel can be prevented.

[0023]

[Embodiment of the Invention] In order to adjust the presentation of the molten slag in the ladle after deoxidation processing termination to the proper range, it is good to control the outflow of a slag as much as possible, and to add calcined lime, a natural magnesia, a dolomite, lime aluminates, etc. as a flux first, in case tapping of the molten steel is carried out to a ladle from steel-manufacture furnaces, such as a converter. Moreover, in order to adjust the content of the sum total of FeO and MnO in a slag, slag modifiers, such as aluminum ashes and an aluminum-CaO system, may be added.

[0024] The molten steel by which tapping was carried out into the ladle is decarbonization-processed and deoxidation processed with vacuum processors, such as RH and DH. Flux is added to the molten steel in a vacuum tub by this vacuum downstream processing, and the presentation of the molten slag in the ladle after vacuum processing is adjusted.

[0025] Flux can be added after taking about 1 to 3 minutes after addition of deoxidizers, such as aluminum, in case flux is added to the molten steel in a vacuum tub. aluminum 2O3 generated in case deoxidation processing is carried out by aluminum etc. etc -- it is better to add flux, after returning molten steel after [ aluminum addition ] 3 minutes or more in order to make molten slag absorb an oxide efficiently. In addition, in order to make flux reach the interface of molten slag and molten steel effectively, it is desirable after addition of flux to continue the ring current of molten steel more than for 2 minutes.

[0026] With the approach of this invention, the molten slag in the ladle after deoxidation processing termination is CaO-aluminum2O3-MgO-SiO2. A system is made into a principal component system, and it adjusts so that it may become the presentation which contains FeO and MnO in this as a low-grade oxide. however, Fe 2O3 of extent mixed from the slag at the time of tapping from a converter etc., P2 O5, and TiO2 etc. -- an unescapable impurity may be included. Below, the presentation of the molten slag in the ladle after deoxidation processing termination is explained concretely.

[0027] CaO is 30 - 60 % of the weight (it is only hereafter described as %), and aluminum 2O3. It may be 20 - 50%. There is little effectiveness which absorbs the oxide generated when CaO carries out deoxidation processing with aluminum etc. in less than 30% of molten slag. Moreover, if it exceeds 60%, the temperature of the molten slag which begins to crystallize solid phase will become higher than the temperature of the range mentioned above.

[0028] aluminum 2O3 At less than 20%, the fluidity of molten slag worsens and the effectiveness which absorbs the oxide generated at the time of deoxidation processing decreases. Moreover, even if it exceeds 50%, the same phenomenon happens.

[0029] CaO and aluminum 2O3 It is the range mentioned above and is aluminum 2O3.

Mole-ratio CaO/aluminum 2O3 of receiving CaO When it is two or more, they are MgO or 3 CaO-aluminum 2O3. It becomes easy to crystallize as solid phase. Moreover, this mole ratio is MgO-aluminum 2O3, If aluminum 2O3 is 40% or more less than in two. It becomes easy to crystallize as solid phase.

[0030] MgO may be 10 - 20%. CaO and aluminum 2O3 which were mentioned above It is the range, and when MgO is such range, it becomes easy to crystallize MgO or MgO-aluminum 2O3 as solid phase. MgO cannot crystallize solid phase easily at less than 10%. Since the effectiveness which absorbs the oxide generated when the fluidity of molten slag worsened and carried out deoxidation processing with aluminum etc. will decrease if MgO exceeds 20%, since addition of superfluous flux is caused, the effectiveness is not only saturated, but the temperature fall of molten steel arises. Therefore, MgO may be 10 - 20%.

[0031] SiO2 It may be 10% or less. The temperature which will begin to crystallize solid phase if it exceeds 10% becomes higher than the temperature of the range mentioned

above. In addition, although not limited especially about a minimum, since Si is contained in a flux as a rock, it usually becomes 1% or more.

[0032] The sum total of FeO and MnO is made into 5 - 15%. Although reoxidation of the molten steel from molten slag can be controlled so that there is little sum total of FeO and MnO, it is not necessary to make it fall to 5 etc.% or less which is looked at by the Prior art by the approach of this invention. It is because reoxidation of the molten steel from molten slag can be prevented if solid phase crystallizes to the molten slag in a ladle when it starts continuous casting with 5 - 15%, even if the sum total of FeO and MnO is expensive. Therefore, it is not necessary to become unnecessary [ addition of a superfluous slag modifier ], and to spray oxygen gas on the front face of the molten steel in a vacuum tub, without delaying the decarbonization rate at the time of the decarbonization processing under a vacuum. However, if it exceeds 15%, reoxidation of molten steel will tend to take place. At less than 5%, it becomes impossible to secure the 0.04% or more of the amounts of oxygen in molten steel required for the decarbonization reaction under a vacuum, and an decarbonization reaction not only becomes slow, but may not be able to perform the ingot of super-low carbon steel.

[0033] By the way, since the gestalt of solid phase and crystallized volume % crystallized to molten slag can be presumed now in recent years using thermodynamic count software, it should just utilize these.

[0034] The flux added to the molten steel in a vacuum tub is molten slag to MgO or MgO-aluminum 2O3. When making solid phase crystallize, MgO system clinkers, such as a natural magnesia, a dolomite clinker, the brick waste with same these and presentation, etc. are good. Moreover, 3 CaO-aluminum 2O3 When making solid phase crystallize, the brick waste with these same calcined lime which uses CaO as a principal component, dolomite, clinker and these, and presentations is good.

[0035] The particle size of the flux to add has that good by which 90% or more enters among 1-30mm. In less than 1mm, it is drawn in the exhaust air system of a vacuum processor.

Moreover, it rises to surface near the dip tube immediately, without homogeneity distributing, even if it will not be invaded into flux by molten steel at the time of addition, and it will not be carried in, if it exceeds 30mm, but remains on the molten steel front face in a vacuum tub or is conveyed by molten steel up to the outside of a vacuum tub, and becomes a lump.

[0036] Although the addition of flux is based on the presentation of the slag in the ladle before decarbonization processing, an amount, etc., it is good to be referred to as 2kg or less per molten steel t. It is because the fall of molten steel temperature becomes large, so the need of spraying oxygen gas on the molten steel front face of a vacuum tub, and raising the temperature of molten steel on the contrary will come out if it adds exceeding 2kg.

[0037]

[Example] Corresponding to the trial shown in Table 1 which mentions 270t super-low carbon steel later, 8 \*\*\*\*\*'s was ingoted using the converter and RH vacuum processor (it is only hereafter described as RH). The molten steel temperature in the ladle after 0.02 - 0.06% of C, 0.01 - 0.2% of Mn, 0.01 - 0.03% of Si, and tapping of the chemical composition of the molten steel before the vacuum processing after [ a converter to ] tapping was 1660-1690 degrees C. In addition, in order to make adjustment of a next slag presentation more reliable on the occasion of tapping, the slag outflow from a converter was controlled as much as possible. To the molten slag in the ladle just behind tapping, the natural magnesia was added as a flux and aluminum ashes and aluminum-CaO system flux were suitably added as a slag modifier.

[0038] Next, using RH, decarbonization processing was performed under the vacuum until the carbon content in molten steel became 0.005% or less. It deoxidized by having added aluminum to the molten steel in a vacuum tub after that, and aluminum content in molten

steel was adjusted to 0.02 - 0.06%.

[0039] The sample of the molten slag in a ladle was extracted before decarbonization processing, X-ray fluorescence was performed, and the presentation of molten slag was checked. In order to refer to the presentation of the checked molten slag and to adjust the presentation of the molten slag after deoxidation processing, the flux of a dolomite clinker or a natural magnesia was added to the molten steel in a vacuum tub after [ of aluminum addition for deoxidation processing ] about 6 minutes using alloy addition equipment. What goes into the range of 1-13mm 95% was used for the particle size of flux. The ring current of molten steel was performed for [ of flux ] about 4 minutes after addition. Then, the sample of the molten slag in a ladle was extracted and X-ray fluorescence was performed.

[0040] Moreover, it was made to be in a liquid phase condition with the uniform part which holds molten steel temperature at 1600 degrees C or more, and contacts the molten steel of molten slag through down stream processing in RH.

[0041] Continuous casting of the molten steel after deoxidation processing termination was carried out to the cast piece of the thickness of 250mm, and a cross-section configuration with a width of face of 1250mm.

[0042] The prevention effectiveness of reoxidation of molten steel was evaluated by calculating value deltaaluminum which deducted aluminum content in the molten steel in the tundish measured during continuous casting from aluminum content in the molten steel after deoxidation processing termination. Moreover, the molten steel in tundish was extracted and the total amount of oxygen in molten steel was measured.

[0043] The cross-section sample was extracted from the obtained cast piece, and the total amount of oxygen and cleanliness of a cast piece were investigated. The total amount of oxygen of a cast piece analyzed the total amount of oxygen of three samples extracted from the location of directly under [ of a cross-section sample / surface ], 1/4 thickness, and 1/2 thickness, and calculated it by the average. The cleanliness of a cast piece is JIS. G 10cm<sup>2</sup> which followed the test method specified to 0555 and were extracted from the front face of a cast piece in the location less than 10mm directly under a front face It investigated by carrying out microscope observation of the sample of \*\*\*\*\*ed by 400 times. By making into a characteristic 1.00 the results of an investigation of the cleanliness of the cast piece of trial No.1 of the example of this invention mentioned later, indexation of the results of an investigation of the cleanliness of the cast piece of other trials was carried out, and they were evaluated.

[0044] Moreover, using the presentation of the molten slag analyzed after adjusting a slag presentation after deoxidation processing, thermodynamic count software was used and the gestalt and the rate of solid phase of solid phase which are crystallized to molten slag with the fall of the temperature of molten slag were computed.

[0045] A test condition and a test result are shown in Table 1.

[0046]

[Table 1]

表1

試験 No.	取 締 内 の フ ラ グ 製 成 (重量%)							Δ A I (*1) (%)	タングステン 内の溶剤 の全酸素 量 (ppm)	錫片の 全酸素 量 (ppm)	錫片の 清浄度 の指標 数 (-)	スラグに 抽出する 錫相の 割合 (%)	
	CaO	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	MgO	FeO	MnO	FeO+MnO						
本 試 験 例	1	38.9	8.1	31.8	10.9	4.8	2.8	7.6	0.002	27	19	1.00	1.0
	2	36.1	8.9	29.1	12.1	7.8	3.2	11.0	0.002	24	18	0.98	2.3
	3	38.5	9.1	26.5	12.8	7.4	3.1	10.5	0.003	25	17	1.00	2.1
	4	37.4	7.4	35.2	12.1	3.5	1.8	5.3	0.002	24	18	0.87	1.5
	5	35.4	8.8	38.6	12.3	7.0	2.2	10.2	0.001	21	18	0.84	5.1
	6	49.2	8.1	25.0	15.1	5.6	3.2	8.8	0	22	18	0.92	8.7
比較 例	7	39.6	8.1	39.2	6.7	2.8	3.8	6.4	0.01	45	35	1.45	0
	8	34.5	7.6	38.2	7.4	7.1	3.3	10.4	0.013	50	33	1.88	0

\*1 : 脱酸処理終了後の溶鋼中の A I 含有率からタングステン内の溶鋼中の A I 含有率を引いた値。

[0047] In trial No.1-6 of the example of this invention, the presentation of the molten slag in the ladle after deoxidation processing termination was considered as the presentation of the range specified by this invention. The value of deltaaluminum which shows extent of reoxidation of the molten steel in these trials was as low as 0.003% or less, tundish and the total amount of oxygen of a cast piece were also as low as 20 and 20 ppm or less respectively, and the cleanliness of a cast piece was also 1.00 or less characteristic, and was a result with good all.

[0048] It is because solid phase crystallized to the molten slag in a ladle after continuous casting initiation that had little reoxidation of molten steel and whose cleanliness of the total amount of oxygen of molten steel and a cast piece etc. was good although the content of the sum total of FeO and MnO in the molten slag in the ladle after deoxidation processing termination was as high as 5 - 11%. That is, in the result computed using thermodynamic count software from the analysis value of a presentation of the molten slag after adjusting a presentation, it has presumed that solid phase did not crystallize to the molten slag in a ladle, but the solid phase of a MgO phase had crystallized about 1 to 9% after continuous casting initiation before continuous casting termination from after deoxidation processing termination before initiation of continuous casting.

[0049] It reached trial No.5, and \*\*aluminum was low, molten steel and the total amount of oxygen of a cast piece were also low at 6, and the cleanliness characteristic of a cast piece was also the good result of presuming solid phase to have crystallized mostly especially in 0.95 or less low value.

[0050] The example of a comparison reached trial No.7 and it considered as the presentation out of range which specifies the presentation of the molten slag in the ladle after deoxidation processing termination by this invention in 8. MgO content is low at trial No.7, and it is aluminum 2O3 further at trial No.8. Mole-ratio CaO/aluminum 2O3 of receiving CaO in spite of being less than two, it is aluminum 2O3. Content considered as less than 40% of presentation of each molten slag. Therefore, the last stage of continuous casting has also been presumed that solid phase does not crystallize to molten slag.

[0051] The value of deltaaluminum which shows extent of reoxidation of the molten steel of these trial No.7 and No.8 was as high as 0.01% or more, the molten steel in tundish and the total amount of oxygen of a cast piece were also as high as 40 and 30 ppm or more respectively, and the cleanliness of a cast piece was also 1.00 or more characteristics, and was results with bad all.

[0052] Drawing 1 is drawing showing the effect the presentation of the molten slag in the ladle after deoxidation processing termination affects reoxidation of molten steel. It is the aluminum content 0 in the molten steel immediately after deoxidation processing termination [aluminum] about aluminum content in the molten steel in the lundish under continuous casting [aluminum]. The value [aluminum]/0 which \*\*(ed) Relation with continuous casting time amount is shown about trial No. 1, and 5, 6 and 8.

[0053] In trial No. 1 which can be presumed that solid phase crystallizes at least 1% to molten slag as compared with trial No.8 presumed that solid phase does not crystallize to molten slag, reoxidation of molten steel is understood that the effectiveness of reoxidation prevention of molten steel is remarkable as it is controlled and its rate of solid phase increases like trial No.5 and No.6 further.

[0054]

[Effect of the Invention] By application of the approach of this invention, reoxidation of the molten steel from the molten slag in a ladle can be controlled, without spoiling the decarbonization rate at the time of the decarbonization processing under a vacuum. Moreover, lock out of a submerged nozzle can be prevented in the case of continuous casting, and it is still more possible to ingot the super-low carbon steel excellent in the detergency. It cannot be overemphasized that \*\*\* prevention and \*\*\* prevention can be performed by selection of suitable flux. Moreover, it becomes reducible [ a manufacturing cost ] from such effectiveness.

[Translation done.]

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## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The presentation of the molten slag in the ladle after deoxidation processing termination is drawing showing the effect affect reoxidation of molten steel.

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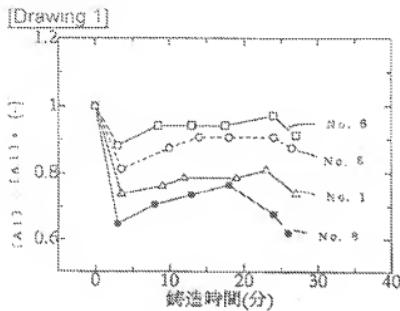
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(54)【発明の名称】 清浄性に優れた極低炭素鋼の溶銬方法

(55)【要約】

【課題】清浄性に優れた極低炭素鋼の溶銬方法の提供、  
【解決手段】真空中で取扱内の溶銬を脱酸処理した後、  
脱酸処理することにより極低炭素鋼を製造する方法において、脱酸処理終了後の取扱内の溶融スラグの生成が、  
重量%で C<sub>eq</sub>O : 3.0~6.0%, SiO<sub>2</sub> : 1.0%以下, Al<sub>2</sub>O<sub>3</sub> : 2.0~5.0%, MgO 1.0~2.0%な  
らびにFeOのおよびMnOの合計が5~15%となるよ  
うに、真空処理工程で取扱内の溶融スラグの組成を調整  
する。

## 【特許請求の範囲】

【請求項1】真空下で取扱内の溶鋼を脱酸処理した後、脱酸残渣することにより低炭素鋼を製造する方法において、脱酸処理終了後の取扱内の溶鋼スラグの種成が、重量%で、C: 0.3%～0.6%，Si: 0.1%以下(A)，O: 2.0%～5.0%，Mg: 0.1%～2.0%ならびに上記よりMg: 0.1%の合計が(A)～(B)となるように、真空処理工程で取扱内の溶鋼スラグの種成を調整することを特徴とする清浄性に優れた板厚炉系鋼の治製方法。

## 【発明の実用的範囲】

## 【0001】

【発明の属する技術分野】本発明は、清浄性に優れた低炭素鋼の溶製方法に関するとくに真空処理工程での取扱内の溶鋼スラグ組成の調整を特徴とする溶製方法に関する。

## 【0002】

【従来の技術】表面欠陥が少なくてかつ成形性に優れていることが要求される自動車の外装用鋼板には、低炭素鋼が用いられており、溶製の際には、鋼の極低炭素化および高清浄化対策が採用されている。

【0003】極低炭素鋼を溶製する際の脱酸方法としては、真空下でも脱酸溶鋼に脱酸反応を起こさせる方法が一般的である。すなわち、脱酸炉の脱酸炉より脱酸含有率があり、0.2%～1.0%重量%の未脱酸溶鋼を脱酸炉に供給し、その後、真空下で溶鋼中の脱酸または溶鋼中のスラグなどの外部から供給される脱酸と溶鋼中の脱酸とを反応させ、脱酸含有率があり、0.01～0.05%重量%になるまで脱酸する。

【0004】上記の脱酸反応の際に、十分な脱酸速度を得るために必要な溶鋼中の脱酸含有率は0.1%～0.5%重量%以上であることが知られている。このような脱酸含有率の高い溶鋼を脱酸炉の脱酸炉で得る場合、スラグ中の低炭素化物であるMgOとMnOの合計率の合計が(A)～(B)重量%程度と高くなる。

【0005】真空下での脱酸残渣は(A)による脱酸処理を行った後低炭素鋼鋼では、通常用いられる脱酸装置が終了するまでの間に、溶鋼中の(A)とスラグ中の低炭素化物が反応する。この反応により(A)の酸化物(A<sub>1</sub>，O<sub>1</sub>)が生成する。この酸化物の一部は脱酸処理中にクンディッシュ内や精炼炉内の溶鋼から除去されずに钢片に残存して非金属介在物となり、钢の清浄性を悪化させる。

【0006】この(A<sub>1</sub>，O<sub>1</sub>)の非金属介在物は、钢片の表面近傍に偏析やすく、そのため自動車の外装用鋼板の表面欠陥となったり、また、脱酸終点で溶鋼ノズルから噴射する原因となったりする場合がある。脱酸ノズルが喷射すると漏れがでかくなり、生産性が阻害されるばかりでなく、漏れノズル内を通過する溶鋼に溶けが生じて溶鋼内の流動状態が変化し、(A)の酸化物など

が钢片の表面近傍に集積し、钢片に表面欠陥が生じる。さらにこれが脱酸ノズルの喷嘴を助けるために、脱酸ノズルの上部より吹き込まれるAr等の不活性ガスの流量を増加する必要がある。多量に吹き込まれた不活性ガスも、钢片の表面近傍に堆積され、残留した場合には、脱酸炉の炉底部溶鋼の一部となる。このような脱酸炉の表面欠陥を防止するため、钢片や熱間圧延した脱酸用耐材の表面を手入れすることは、经济性や生産性の面から大切な問題となる。

【0007】そこで、鋼中の(A<sub>1</sub>と脱酸を起こしやすい)脱酸炉のスラグ中のFeOやMnOなどの低級酸化物の含有率を、脱酸炉の脱酸炉からの出鋼時、または真空下での脱酸処理前に下げる対策が採用されてきた。

【0008】たとえば、特開平1-239137号公報に示される方法では、脱酸炉からの出鋼時または出鋼後の脱酸炉のスラグに、スラグ改良剤を添加してスラグ中のFeOおよびMnOの合計の含有率を5重量%以下にして、その後、真空中での脱酸残渣前に上吹きランプから真空中の溶鋼の表面に酸素ガスを吹き付ける方法を採っている。

【0009】この方法では、真空中の溶鋼表面に上吹きランプから酸素ガスを吹き付けるが、その理由は、スラグ改良により真空中での脱酸処理前のスラグ中の低級酸化物の含有率を低下して、脱酸反応に寄与する低級酸化物からの酸素供給量を低下して、脱酸反応に必要な酸素が不足するからである。しかし、真空中の溶鋼表面に吹き付けられる酸素ガスにより、溶鋼中のFe<sub>2</sub>O<sub>3</sub>やMnOなどが酸化され、FeOやMnOなどの低級酸化物が消失し、結晶スラグ中の低級酸化物の含有率が高くなる。また、出鋼時のスラグ中のFeOおよびMnOの合計の含有率を5%以下にするために、多量の改良剤および清浄剤を出鋼中に添加するので、脱酸炉の脱酸温度の降低が大きいことなどの問題がある。

【0010】一方、真空中での脱酸処理後に(A<sub>1</sub>)による脱酸処理を行った後に、真空中の溶鋼に脱酸物系の脱酸剤を添加することにより、鋼中の(A<sub>1</sub>)と脱酸を起こしやすいFeOやMnOなどの低級酸化物の含有率を低下させたり、脱酸炉のスラグと溶鋼の界面を遮断する対策などが採用されてきた。

【0011】特開平3-183722号公報では、真空中での脱酸処理後に(A<sub>1</sub>)による脱酸処理を行った後に、真空中の溶鋼に脱酸物系の脱酸剤を添加し、スラグと溶鋼の界面にこの脱酸物を介在させる方法が示されている。MgOを、真空中のシートまたは真空中の脱酸炉に溶鋼中に浸漬した所から、2～5kg/m<sup>2</sup>程度濃度を添加する方法である。

【0012】この方法では、MgOの添加量が多すぎるので、吐き出されたスラグと溶鋼の界面に均一に分散せず、局部的に堆積したりして、MgOが脱酸の効果を劣化して堆積がかかるばかりでなく、脱酸炉の溶鋼の温度が大きくなり

る場合がある。そのため、真空槽内の溶媒表面に酸素ガスを吸引させて溶媒の温度を上げる必要があり、結局、清浄性に劣る鋼を得られないという問題がある。

#### 【0013】

【発明が解決しようとする課題】本発明は、真空中での脱炭処理時の脱炭濃度を保なうことなく、また、取扱い内での溶媒スラグからの溶媒の再酸化を抑制し、かつ連続鉄造の際に溶波／アルの鋼を防止して、清浄性に優れた脱炭處理鋼を溶製できる方法を提供することを目的とする。

#### 【0014】

【課題を解決するための手段】本発明の要旨は、真空中で脱炭内の溶媒を脱炭処理した後、脱炭処理することにより低価値鋼を製造する方法において、脱炭処理終了後の取扱い内の溶媒スラグの組成が、重量%で、C : 0.4、S : 0.0~0.6%、Si : 0.1%以上、Al : 0.0、Mg : 0.1~0.2%、Fe : 0.0および以上の合計が1.5%となるように、真空中処理工程で取扱い内の溶媒スラグの組成を調整する清浄性に優れた低価値鋼の溶製方法にある。

【0015】本発明で対象とする低価値鋼とは、炭素含有率がおよそ0.1%を基準以下の中である。

【0016】本発明でいう真空処理工程、すなわち、真空中での脱炭処理および脱酸処理の工程とは、RHやVDなどの連続型真空処理装置を用いた処理工程を意味する。このよろうな真空処理工程により清浄性に優れた低価値鋼を溶製するには、真空中で脱炭処理した後の脱炭処理後に、脱炭内の溶媒スラグからの溶媒の再酸化を防止することが効果的である。上述したように、Alによる脱酸処理を行った低価値鋼溶鋼では、溶鋼中のAlと脱炭内の溶媒スラグ中の低価値化が反応からである。

【0017】脱炭内の溶媒スラグからの溶鋼の再酸化を防止するには、脱炭内の溶媒スラグと溶鋼の界面を遮断する方法が最も効果的である。このような界面を遮断する方法としては、脱炭処理後の溶媒スラグに固相を晶出させるのが、最も効果的である。その理由は、脱炭内の溶媒と直接接触して溶鋼を再酸化させているのは、溶媒底層の溶媒スラグであり、固相のスラグの鷲合に、溶鋼の再酸化濃度が著しく低下し、実質、溶鋼の再酸化は起こらないからである。

【0018】本発明者は、脱炭処理後の取扱い内の溶媒スラグにこの固相を晶出させる時期を適切に選択することとが、とくに重要であることを知見した。すなわち、脱炭処理終了後から連続鉄造を開始するまでは、溶媒スラグによる溶鋼の再酸化が生じるよりも、むしろ、この時期には、脱炭処理時および脱酸処理後に溶鋼中に生成したAl<sup>3+</sup>、Mg<sup>2+</sup>などの酸化物が、溶鋼中を浮上して取扱い内の溶媒スラグに吸着されている。つまり、取扱い内の溶媒スラグによる溶鋼の再酸化は、連続鉄造を開始した後の

連続鉄造中に抑制することが必要である。すなわち、脱炭処理後の溶媒スラグを開始する時期に、脱炭内の溶媒スラグに固相を晶出させれば効果的である。

【0019】さらに、本発明者らは、脱炭処理後の脱炭内の溶媒スラグの組成を、上述した組成とすることにより、連続鉄造を開始する時期に溶鋼スラグに固相を晶出させることができることを知見した。

【0020】取扱いおよび連続鉄造のクンディッシュの容量によって若干異なるが、脱炭内の溶鋼よりクンディッシュ内の溶鋼の濃度の溶媒濃度に対する過熱度は、通常、過度の細胞の過熱度を持った温度と/or、過熱度が低すぎると、脱炭内の温度が時間とともに低下するため、連続鉄造の途中で、溶鋼が凝固、クンディッシュまたは脱炭内で、急速に凝固して、錆造できなくなる。また、過熱度が高すぎると、鋼内での凝固層が溶解してブレーカウットが発生しやすくなる。さらに、鋼に固有の凝固温度は、鋼の供給含有率によっては決まる。したがって、本発明が対象とするC含有率が0.01%を基準以下(0.01%)の低価値鋼溶鋼の連続鉄造開始時の脱炭内の溶鋼温度は、1.590~1.620°C程度とするのが望ましい。なお、取扱いの溶鋼に摂している溶媒スラグと溶鋼の温度は、ほぼ同じである。

【0021】このことから、連続鉄造を開始する時期をすなわち、1.590~1.620°Cの溶媒スラグの温度で、脱炭処理後の取扱い内の溶媒スラグに固相を晶出せられ、溶鋼の再酸化防止に対して効果的であることが分かった。

【0022】このとき、溶媒スラグ中に、少なくとも1~2%程度の固相を晶出させれば、溶媒スラグによる溶鋼の再酸化を防止できる。固相が溶媒スラグに晶出する体積(以下「固相量」と記す)が、上述した程度に少なくても、溶媒スラグの粘性は増大し、溶媒スラグの物理運動を抑制するので、溶鋼の再酸化を防止できる。

#### 【0023】

【発明の実施の形態】脱炭処理終了後の取扱い内の溶媒スラグを適正な量で調整するために、まず、脱炭などの脱酸炉から連続鉄造を開始する際、スラグの混出をできるだけ抑制し、かつ造浄剤として生石灰、天かマグミン、ドロマイト、ライムアルミネートなどを添加するのがよい。また、スラグ中のFeOおよびMnOの合計の含有率を調整するために、Al<sub>2</sub>O<sub>3</sub>やAl<sub>2</sub>O<sub>3</sub>系などのフランジ改良剤を添加してもよい。

【0024】取扱い内に晶出された溶鋼は、RHやVDなどの真空処理装置により、脱炭処理および脱酸処理される。この真空中処理工程で真空中内の溶鋼に酸化剤を添加して、真空中処理後の脱炭内の溶媒スラグの組成を調整する。

【0025】真空中内の溶鋼に酸化剤を添加する際には、Alなどの脱酸剤の添加量を1~3分程度してから、端溶

剤を添加できる。A<sub>1</sub>などにより脱脂処理する際に生成するMgOなどの酸化物を滑触スラグに効率的に吸収するためには、A<sub>1</sub>添加量3分以上滑触を標準した後に脱脂剤を添加する方がよい。なお、脱脂剤を効率的に滑触スラグと滑触の界面に到達させるためには、脱脂剤の添加量、2分間以上滑触の噴流を継続することが望ましい。

【0026】本発明の方では、脱脂処理終了後の脱脂内の滑触スラグが、CaO-A<sub>1</sub>O<sub>3</sub>-MgO-C<sub>6</sub>O<sub>7</sub>系を主成分系とし、これに低級酸化物としてMgOおよびFe<sub>2</sub>O<sub>3</sub>を含む組成となるように操作する。ただし、脱脂粉からの出鋼時のスラグから混入する程度のFe<sub>2</sub>O<sub>3</sub>、Fe<sub>3</sub>O<sub>4</sub>、Al<sub>2</sub>O<sub>3</sub>などの不可避的不純物を含んでも構わない。以下に、脱脂処理終了後の取扱内の滑触スラグの組成を具体的に説明する。

【0027】CaOは3.0～6.0重量%（以下、単に%と記す）、Al<sub>2</sub>O<sub>3</sub>は2.0～5.0%とする。CaOが3.0%未満の滑触スラグでは、A<sub>1</sub>などで脱脂処理する時に生成する酸化物を吸収する効果が少ないので、6.0%を超えると、滑触を出し始めの滑触スラグの温度が、上述した範囲の温度よりも高くなる。

【0028】A<sub>1</sub>O<sub>3</sub>が2.0%未満では、滑触スラグの流动性が悪くなり、脱脂処理時に生成した酸化物を吸収する効果が少なくなる。また、5.0%を超えてても、同様の現象が起こる。

【0029】CaOおよびAl<sub>2</sub>O<sub>3</sub>が上述した範囲であって、A<sub>1</sub>O<sub>3</sub>に対するCaOのモル比CaO/A<sub>1</sub>O<sub>3</sub>が2以上の場合、MgOまたは3CaO·A<sub>1</sub>O<sub>3</sub>が滑触として晶出しやすくなる。また、このモル比が2未満では、A<sub>1</sub>O<sub>3</sub>が1.6%以上であれば、MgO·A<sub>1</sub>O<sub>3</sub>が滑触として晶出しやすくなる。

【0030】MgOは1.0～2.0%とする。上述したようなCaOおよびAl<sub>2</sub>O<sub>3</sub>の範囲で、かつMgOがこのような現象の場合には、MgOまたはMgO·A<sub>1</sub>O<sub>3</sub>が滑触として晶出しやすくなる。MgOが1.0%未満では滑触が晶出しにくい。MgOが2.0%を超えると滑触スラグの流动性が悪くなり、A<sub>1</sub>などで脱脂処理した時に生成した酸化物を吸収する効果が少なくなるので、その効果が發揮するばかりでなく、滑触が脱脂剤の添加を妨げていることから、滑触の温度低下が生じる。したがって、MgOは1.0～2.0%とする。

【0031】MgOは1.0%以下とする。1.0%を超えると滑触を出し始めの温度が、上述した範囲の温度よりも高くなる。今ね、下限については、とくに制限しないが、3.0%は鉄石として選別時に含まれるので、通常1%以上となる。

【0032】Fe<sub>2</sub>O<sub>3</sub>およびMnOの合計は2.0～1.5%とする。Fe<sub>2</sub>O<sub>3</sub>およびMnOの合計が少ないほど滑触スラグからの滑触の再酸化が抑制できるが、本発明の方では、従来の技術に見られるより少ない量（1.0%など）に低さ

せててもよい。Fe<sub>2</sub>O<sub>3</sub>およびMnOの合計が2.0%と高くても、滑触鉄造を開始する時点で、脱脂内の滑触スラグに脱脂粉が混入すれば、滑触スラグからの滑触の再酸化を防止できらからである。したがって、滑触下での脱脂処理時の脱脂速度を遅らせることがなく、脱脂粉フラグ改質剤の添加も不要となり、また、真空槽中の滑觸の表面に酸素ガスを吹き付ける必要もない。ただし、1.5%を超えると、滑触の再酸化が起こりやすい。5.0%未満では、真空槽での脱脂反応に必要な脱脂中の酸素量0.04%以上を確保できなくなり、脱脂反応が悪くなるばかりかなく、脱脂粉フラグの溶解ができない場合がある。

【0033】ところで、滑触スラグに晶出すの困難な状況で晶出した体積は、近年、熱力学的計算ソフトウェアを用いて推定することができるようになってきたので、これらを活用すればよい。

【0034】真空槽内の滑触に添加する脱脂剤は、滑触スラグから脱脂する量は3CaO·A<sub>1</sub>O<sub>3</sub>の脱脂を晶出せ場合は、炭酸マグネシウムなどの脱脂粉クリンカー、ドロマイトクリンカーおよびこれらと組成が同じレンガ粉などである。また、3CaO·A<sub>1</sub>O<sub>3</sub>の脱脂を晶出せ場合は、CaOを主成分とする生石灰、ドロマイト、これらのクリンカーおよびこれらと組成が同じレンガ粉がある。

【0035】液相する脱脂剤の粒径は、1～3.0mmの間にあり、以上が入るもののがよい。1mm未満では、真空処理装置の脱脂剤に引き込まれる。また、3.0mmを超えると、脱脂粉は脱脂槽に侵入、攪拌されず、真空槽内の滑触表面に堆積したり、または真空槽外まで滑触により搬出されても、均一に分散されずにただちに淡渣滓近傍で上昇して、固まりとなったりする。

【0036】脱脂剤の添加量は、脱脂処理前の取扱内のスラグの組成、量などにもよるが、滑触当たり2kg以下とするのがよい。2kgを超えて添加すると、滑触温度の低下が大きくなるため、かえって、真空槽の滑触表面に酸素ガスを吹き付けて、滑触の温度を上げる必要が出てくるからである。

【0037】【実施例】脱脂および日立真空処理装置（以下、単にHJHと記す）を用いて、2.7t以上の極低炭素鋼を熔融する表1に示す試験に対してスチーラージ溶解した。脱脂粉から出鋼後の真空処理槽の滑触の化学組成は、CaO: 0.2～0.6%、MgO: 0.1～0.2%、SiO<sub>2</sub>: 0.1～0.15%、Al<sub>2</sub>O<sub>3</sub>: 0.3%。出鋼後の取扱内の滑触濃度は1.6～1.7～1.9%であった。次に、出鋼に際して、次のスラグ組成の脱脂粉をより確実にするために、脱脂粉からスラグ流出を努力抑制するようにした。出鋼直後の取扱内の滑触スラグに、脱脂粉としてリマグネシウム、スラグ改質剤として、A<sub>1</sub>灰、A<sub>1</sub>-MgO系フラックスを適宜添加した。

【0039】に、EHTを用いて、範囲中のA1含有率が0.005%以下となるまで真空下で脱酸処理を行った。その後に、真空槽内の溶剤中にA1を添加して脱酸を行い、溶剤中のA1含有率を0.02%へ、しも%に調整した。

【0039】脱酸処理後に取扱内の溶剤スラグのサンプルを採取し、蛍光X線分析を行って溶剤スラグの組成を確認した。確認した溶剤スラグの組成を参考にして、脱酸処理後の溶剤スラグの組成を調整するために、脱酸処理のためのA1添加から6分後に、ドロマイドクリンカーナまたは天然マグマアシの脱酸剤を、合金添加装置を利用して真空槽内の溶剤に添加した。標準剤の投げは、1×1.3mの範囲に9粒入れるものを用いた。媒洗剤の添加時間4分間、溶剤の攪拌を行った。その後、貯蔵内の溶剤スラグのサンプルを採取し、蛍光X線分析を行った。

【0040】また、EHTでの処理工序を通じて、溶渣温度を160°C以上に保持して溶剤スラグの溶剤と接触する部分が約1~2cm程度であるようにした。

【0041】脱酸処理終了後の溶剤を、厚み2.5mm、幅125.0mmの断面形状の鉄片に連続鍛造した。

【0042】溶剤の再酸化の防止効果は、脱酸処理終了後の範囲中のA1含有率から連続鍛造中に測定したタン

ゲイッシュ内の溶剤中のA1含有率を差し引いた値(%)を求ることにより評価した。また、タンゲイッシュ内の溶剤を採取し、溶剤中の全酸素量を測定した。

【0043】得られた鉄片から横断面サンプルを採取し、鉄片の全酸素量および清浄度を測定した。鉄片の全酸素量は、横断面サンプルの表面直下、1/4厚さより1/2厚さの位置から採取した2層の試料の全酸素量を平均し、その平均値で求めた。鉄片の清浄度は、JIS G 0154に規定する清浄方法に則り、鉄片の表面から清浄直下1.0mm以内の位置で採取した10cm<sup>2</sup>の砂漿面積の試料を400倍で測定鏡観察することにより測定した。後述する本発明例の試験No.1の鉄片の清浄度の測定結果を指標1.00として、他の試験の鉄片の清浄度の測定結果を指標化して評価した。

【0044】また、脱酸処理後にスラグ組成を調整した後の、分析した溶剤スラグの組成を用いて、熱力学的計算ソフトウェアを利用して、溶剤スラグの温度の低下とともに溶剤スラグに混出する固相の形態および固相率を算出した。

【0045】試験条件および試験結果を表1に示す。

【0046】

【表1】

表1

試験 No.	取扱内溶剤スラグ組成(重量%)						△A1 含 (%)	シバゲイ 内の全酸 素量 (ppm)	鉄片の 全酸素量 (ppm)	鉄片の 清浄度 (%)	スラグに 混出する 固相 率(%)	
	GdP	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	MgO	FeO	SiO <sub>2</sub>	FeO-MnO					
小 試験	1	38.0	8.1	31.8	16.9	4.8	2.8	7.6	0.992	27	19	1.00
	2	36.1	8.9	29.1	12.1	7.8	3.2	11.9	0.992	24	18	0.98
	3	38.6	9.1	25.5	12.8	7.4	3.1	10.5	0.993	25	17	1.00
	4	37.4	7.4	35.2	12.1	3.5	1.8	5.3	0.992	34	16	0.97
	5	36.5	8.9	40.5	12.3	7.9	3.4	10.1	0.991	31	18	0.94
	6	45.2	8.1	25.8	16.1	5.6	3.8	8.6	0	22	16	0.82
大 試験	7	39.8	8.1	36.2	6.7	2.6	3.6	8.4	0.901	45	35	1.46
	8	34.5	7.6	38.2	7.4	7.1	3.3	10.4	0.918	57	33	1.86

\* 1. 脱酸処理終了後の範囲中のA1含有率からタングイッシュ内の溶剤中のA1含有率を引いた値。

【0047】本発明例の試験No.1~6では、脱酸処理終了後の取扱内の溶剤スラグの組成を本発明で規定する範囲の組成とした。これら試験での溶剤の再酸化の程度を示す△A1の値は0.003%以下と低く、タングイッシュおよび鉄片の全酸素量も、それぞれ3.0および2.0ppm以下と低く、また、鉄片の清浄度も指数1.00以下であり、いずれも良好な結果であった。

【0048】脱酸処理終了後の取扱内の溶剤スラグ中のFeOおよびMnOの合計の含有率が約1.1%と高いにも関わらず、溶剤の再酸化が少なく、溶剤の全酸素量が上り鉄片の清浄度などが良好であったのは、脱酸処

理終了後溶剤内の清浄度は固相が混出しないためである。すなわち、粗鉄を鋼精製した後の溶剤スラグの組成の分析結果から熱力学的計算ソフトウェアを用いて算出した結果では、脱酸処理終了後から還元融清の開始まで約1時間では、取扱内の溶剤スラグには固相が混出せず、還元融清開始から溶剤が還元されまでの間に、MgO相の固相が1~2%程度混出していることが推定された。

【0049】とくに、粗鉄が多く混出していると推定される鉄片は、もうまでもではなく、△A1が低く、溶剤および鉄片の全酸素量も低く、鉄片の清浄度指数0.9以下以下の低い値で、良好な結果であった。

【0050】比較的の試験No. 7および8では、脱酸処理終了後の溶鋼内の溶融スラグの組成を本発明で規定する範囲外の組成とした。試験No. 7では、Mgの含有率が低く、試験No. 8では、さらにもAl<sub>2</sub>O<sub>3</sub>に対するMgOのモル比C<sub>3</sub>O : Al<sub>2</sub>O<sub>3</sub>が2未満であるにもかかわらず、Al<sub>2</sub>O<sub>3</sub>含有率が40%未満の、それぞれの溶融スラグの組成とした。そのため、溶銑铸造の初期でも溶融スラグに固相が晶出しないと推定できた。

【0051】これら試験No. 7およびNo. 8での溶鋼の再酸化の程度を示すAl<sub>2</sub>O<sub>3</sub>の量は、0.1%以上と高く、タンディッシュ内の溶鋼および鉄片の全酸素量も、それぞれ4.0および3.0 ppm以上と高く、また、鉄片の溶解度も指数1.0以上であり、いずれも悪い結果であった。

【0052】図1は、脱酸処理終了後の取扱内の溶融スラグの組成が溶鋼の再酸化に及ぼす影響を示す図である。連続铸造中のクンディッシュ内の溶鋼中のAl含有率[Al]を脱酸処理終了直後の溶鋼中のAl含有率[Al]<sub>0</sub>と除した値[Al]/[Al]<sub>0</sub>と溶銑铸造

時間との関係を、試験No. 1, 2, 6およびそれに付して示す。

【0053】溶融スラグに固相が晶出しないと推定される試験No. 7に比較して、溶融スラグに固相が1%でも晶出すると推定できる試験No. 1です。溶鋼の再酸化は抑制されており、さらに、試験No. 1およびNo. 6のように固相が多く立ちにしてしまって、溶鋼の再酸化防止の効果が弱めとなっているのが分かる。

#### 【0054】

【発明の効果】本発明の方法の適用により、真空中での脱酸処理時の脱酸速度を抑かうことなく、かつ取扱内の溶融スラグからの溶鋼の再酸化を抑制できる。また、連続铸造の際に浸漬ノズルの剥離を防止でき、さらに、清浄性に優り、耐低温性能を実現することが可能である。適切な鍛溶炉の選択により、飛沫防止や飛沫防止ができることは言うまでもない。また、このような効果から製造コストの削減の問題となる。

#### 【図解の簡単な説明】

【図1】脱酸処理終了後の取扱内の溶融スラグの組成が溶鋼の再酸化に及ぼす影響を示す図である。

【図1】

